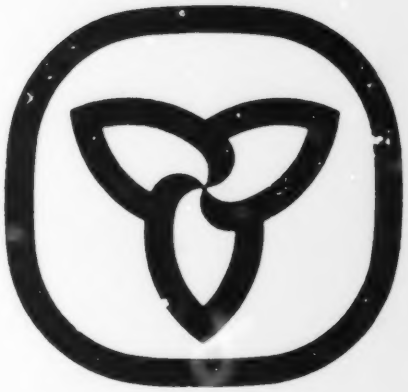

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COMPUTER/COMMUNICATIONS TECHNOLOGY IN SOCIETY: SIGNPOSTS FOR EDUCATION

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SUBJECT

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ANNOTATION

This discussion paper summarizes the ideas and opinions of Canadians in various walks of life vis-a-vis the impact of computer communications technologies on how we live and learn. The introduction discusses the rapid expansion of knowledge and the increasingly urgent need to understand the effects of these technologies and to manage them properly.

Material is in 6 sections, the 1st dealing with improvements and applications: e.g., the trend towards 16 and 32 bit microprocessors; larger storage capacity; reduced memory cost; the CD-ROM disk; networking; increasing standardization; larger, cheaper software packages; extended product lifecycles; and dot-matrix and laser printers. A picture of what the computer industry will provide in the short-, medium-, and long-term is presented.

Section 2 briefly discusses each of the following traditional computer applications: word processing, electronic spreadsheets, database mamangement, graphic presentation, and telecommunications. Integrated software, a combination of applications, is also discussed. Section 3 is concerned with the general implications of computer-communications technologies for society. It considers philosophical issues and outlines the 3 main positions currently adopted in Canada: computer humanism, computer dread, and computer realism.

Section 4 looks at the impact of computer-communications technology on specific aspects of Canadian life and society. It explores the implications for the economy as a whole and employment growth. Developments in the fields of publishing, arts and design, film and video, and computer-aided design and manufacture are briefly discussed. The application of computers in broadcasting is described, and use of computer technology in the physical and life sciences is reviewed.

Section 5 deals with implications for the individual. It focuses on new skills that will be required in the workplace and the importance of a positive attitude towards computer technology by management and staff. Section 6 examines implications for education, the school, and the learner. It discusses: factors governing the introduction of computers in education; key questions about computer technology; benefits at the school level; the "soft library"; the "soft classroom"; computer conferencing; word processing and language development; programming languages and cognitive growth; and the use of LOGO. The need for research on the uses of computers by young children is stressed.

The last section presents the opinions of Canadians in diverse fields with respect to what young people ought to learn about computer technology. It also discusses the roles of educational personnel, calling for accelerated development of teacher education programs.

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COMPUTER/COMMUNICATIONS TECHNOLOGY IN SOCIETY: SIGNPOSTS FOR EDUCATION

1.0 INTRODUCTION

This discussion paper is intended to stimulate thinking about the choices we face in deciding how new, increasingly powerful electronic technologies should influence the ways we live and learn in our society.

The ideas in this document are a composite of thoughts shared with the Ministry of Education by some Canadians who were invited during 1985 to reflect upon the impact of new technologies in particular fields. They are actively involved in such fields as the physical and life sciences, the arts, humanities, social sciences, and education; the communications media; philosophy and ethics; business; and the manufacturing and service industries. The Ministry asked them to identify and describe important current and emerging developments in computer/communications technology with significant implications for society in general and education in particular. The document also includes ideas that foreshadow some possible policy directions for education, along with priorities and strategies for further development.

The specific intent of this discussion paper is (a) to solicit reactions to the ideas it contains about the relationship between new technologies and the way we live and learn, and (b) to seek advice, on the basis of these responses, on the changes that should be made in the education of students in the elementary and secondary schools of Ontario. The responses to this paper will serve as a basis for development of a Ministry statement of directions for the integration of computer/communications technology into the instructional process.

2.0 EXPANSION OF KNOWLEDGE AND ITS APPLICATION

Our age is being enriched by the rapid expansion of knowledge to a degree unprecedented in history. On a global scale, knowledge is increasing faster than our individual or group capability to absorb it and to assess its implications. Much of the new knowledge is in the form of groups of ideas related to one another in systematic ways and applied to solve human problems or achieve new goals. Such systematically related and applied ideas, which we refer to generally as technologies, encompass a surprisingly wide range of activities and applications. Major advances have been made in such technologies as computers, telecommunications, bio-systems (including genetic engineering), geo-physics, fluidics,

cybernetics (in management science), to name only a few. Advances in one technology frequently enhance progress in another: much recent progress in the development of several technologies, for example, has resulted from the application of computers. The merger of computer/communication technologies has speeded up and expanded people's access to information, thus accelerating the production of new knowledge.

All these technologies are affecting society in such varied and profound ways that it is becoming increasingly urgent for us to understand their effects and manage them for the benefit of all. This paper specifically explores the implications of two electronic technologies -- computers and telecommunications -- for our society, and in particular for our ideas about teaching and learning.

3.0 COMPUTER AND COMMUNICATIONS TECHNOLOGIES: IMPROVEMENTS AND APPLICATIONS

3.1 Current and Emerging Technological Advances

Advances in both computer and communications technologies continue to expand the range of their practical applications, and the linking together of these technologies is extending the range yet further. In fact, the merger of computer and communications technologies is creating totally new kinds of capabilities that exceed those of either technology applied separately. As functions that were once distinct are combined, basic changes are occurring in the way people communicate.

Like the earlier technologies described by Marshall McLuhan, these technologies can extend and amplify the human senses. Moreover, we can choose differing configurations in which we wish these extensions to be made, as the following examples illustrate. As a limited-access database, the computer extends the writing mind and the reading eye in radio's one-to-many model; as a public-access bulletin board it extends mind and eye in a many-to-many model unaccomplished by any previous technology; as a stand-alone system it can amplify individual memory and filing and sorting skills; in a local area network it allows the writing mind to communicate at a speed approaching that of voice, and the memory to transfer to another memory large chunks of itself at the stroke of a key; as a large public-access database it extends memory in both time and space and can make it available to individual memories across a nation in both one-to-many and many-to-many configurations.

Despite the myriad applications of computers, resistance to their use persists. One obstacle to their acceptance arises from unrealistic public expectations of what current computer technology can deliver at reasonable cost. High school students with relatively modest equipment can set off a War

Games scenario. Computer graphics capability includes full integration of text, sound and video. Unfortunately, these expectations, based on the "vision" of Hollywood writers and producers, do not reflect the capabilities of the technology accessible to most users. The following is presented as a realistic perspective on the development of computer technology over the next three to five years.

The current trend is toward 16 and 32 bit microprocessors, accompanied by the development of special-purpose micro-processors. The demands that are being made for sophisticated user interfaces, including windowing, multi-tasking, and graphics, have placed more pressure on the traditional 8 bit technology than it can accommodate. Responsive user interfaces, wide colour ranges, animation and other advanced features require sophisticated programs, and, by implication, large and processor-intensive software. Users need more powerful computers simply to make computers simpler to use. They expect powerful tools such as database software, graphics packages, and text processors to be fast as well. These demands are forcing the microcomputer industry to redesign their products to make use of the new generation of micro-processors.

User demand for vast storage capacity is also pushing the industry, and the technology to respond to it is becoming both available and affordable. Four years ago a 5 megabyte hard disk on a micro was considered a luxury. Today 20 megabytes is considered skimping, and disks of 100 megabyte capacity are available. Larger capacity drives have also been developed. Memory capacity is another aspect of storage. In reality, disk and tape storages are makeshift remedies for the deficiencies of memories. The two areas in which memories are currently considered deficient are capacity and volatility.

Until recently, capacity was governed by the cost of 64k blocks of memory, owing to the manufacturing limits on chips. Within the past two years, 256k blocks have become available at about the same cost per block as the 64k chips. The consequence is a 75 percent reduction in memory cost. Deliveries are now being made of 1024k (1 megabit) chips, which will rapidly become the basic memory building blocks for the next three years. This type of chip represents yet another 75 percent cost reduction about eighteen months from now. Still in the experimental stage are 4096k (4 megabit) memories. In future, large memories will be characteristic of even a cheaply built computer, since manufacturers cannot afford the cost of smaller ones.

Volatility refers to the ability of a memory to retain its contents when power is turned off. All cheap memory is volatile. Barring revolutionary discoveries in the next three to four years, however, memory technology will continue to be of the present volatile type for the next decade or so.

The only revolutionary element that might affect storage capacity is the inexpensive and durable CD-ROM disk. These

industry-standard disks represent low cost ($5.00 average cost when purchased in volume) and high capacity (540 megabytes of information storage capacity or approximately the capacity of 1500 IBM PC floppy disks). Coupled with low-cost drives, these disks will become the dominant distribution medium for a large range of database type of software products and may effect revolutionary change in the acceptance of computers as tools in the home and school.

The ability to share information easily is a key development. Networking is only beginning to emerge as an important element of business and school computer systems. Initially, acceptance has been based on the ability to share expensive peripherals among a large number of users. As a side benefit, this type of connection provides users with communications facilities. Proper use of communications networks, however, can enhance the interactivity of users and encourage the adoption of cooperative problem-solving strategies. Networking powerful microcomputers establishes some of the basic elements of supercomputer architecture: a computer is no longer merely a workstation with a wire to permit communication with one or more other users via a network, but rather part of a single expandable system. The concept of shared resources takes on new meaning in such an environment.

Standardization will increasingly become a powerful influence in the computer industry. Users are growing reluctant to accept the cost of redeveloping or repurchasing software with every new hardware or system software modification. Furthermore, users want to be able to move software from system to system regardless of manufacturer and without the need to learn the idiosyncracies of yet another system. Efforts are therefore being made at the international standards level to define computer systems and their components.

The nature of software will also influence users' expectations of computers and thus manufacturers' product development plans. Software packages are increasing in size. Whereas 50 to 60k packages were large four years ago, now 256 to 400k packages are common. At the same time, the retail cost is coming down. Two years ago few packages sold for much less that $300 to $400; today most new software is introduced at the $50 to $150 price range. This trend is unlikely to be reversed.

Increases in engineering costs mean that product life cycles of 18 months -- the norm until recently -- are now expected to be 36 to 48 months. This extension reflects a reluctance on the part of manufacturers to develop new products frequently, and implies that each new generation of computers will represent more dramatic differences in capability.

Printer capability is showing substantial progress. Fixed-font letter-quality printers are common now for high quality printing. However, the pressures of dot-matrix printers with much improved quality, coupled with the introduction of

affordable laser printers, essentially makes fixed-font printers obsolescent. "In-house publishing" has become a popular expression. Students will have ready access to phototype-setting facilities in the next two years. Schools can provide it now at $3500 to $7000, depending on features.

The following is a picture of what the computer industry will provide both in the short term (two to three years), the medium term (four to five years), and the long term.

In the short term, schools will be able to provide the functionality of a 32-bit microcomputer to most users. The system will have a network to permit sharing of peripherals and communications. Memories will be a minimum of one megabyte and will likely be expandable to four megabytes. CD-ROM based databases will begin to appear toward the end of the short term. Such early products should be available in about eighteen months for general interest software users; they are already available for special markets. Colour capability on computers will be broader than at present and colour will begin to overtake monochrome as the normal display. Animation capabilities will be enhanced. Sound will be accommodated by MIDI interfaces. Voice output will still not make any significant impact because of the lack of standards for voice representation.

In the medium term, networking standards will begin to exert a strong influence and will simplify the task of inter-connecting computer products from various vendors in a single common network. Networking will thus become widely adopted. Cheap high-quality printing will become generally available, and phototypesetting capability will become common toward the end of this period. Videodisk, which to date has made little impact, may experience a rebirth of interest as a result of merging CD-ROM and videodisk standards, thus opening the way for development of initial attempts at true interactive video. The computer will begin to show some of the capabilities which have become part of user expectations today.

In the longer term, there will be continued emphasis on more memory, better screen resolution, colour range, and animation capabilities. Integrated computer graphics and video will become readily accessible. Developments in computers will become less visible to users. Technical improvements will continue to lead software development efforts for some time. The products available at the end of the long term will represent evolutionary developments of the short-term products. The user population will shift significantly from the current users, who generally know a lot about computers, to users who employ a computer as they would an appliance. This shift will force improvements in user interfaces. Standards will become established, and computers will increasingly become commodity items.

The marriage of computers with current developments in tele-communications will radically influence the way people acquire information and communicate with each other. Access to

information is continually being expedited, and new ways of linking people through electronic means are being devised. The tremendous communications capacity of satellite systems, especially when coupled with broad-band fiber-optic channels on earth, opens the door to information exchanges that will dwarf our best current predictions.

The technologies which will drive future developments include space manufacture, denser large-scale circuit integration, decreased power requirements, improved mass storage, improved telecommunications and networking capacities, a lessened dependence on machine type, and progressively more transparent and easy-to-use man-machine interfaces.

3.2 Traditional Applications of Computers

Five computer applications enjoy great popularity, chiefly because they embody a good fit between computers (and what they do best) and humans (and what they want most). These applications are word processing, electronic spreadsheets, database management, graphic presentation, and telecommunications. In addition, some of these applications can be combined into what is termed "integrated software".

3.2.1 Word Processing

Word or text processing is the small-computer application best known to the public. In its most recent manifestation (desk-top publishing), the manipulation and presentation of text, with or without graphic inserts, promises to change the face of small publishing ventures. Word processing in general has already altered the expectation of persons who generate and receive printed material; they expect higher quality, letter-perfect copy. In the educational system, word processing will require a rethinking of curriculum elements related to writing (printing, writing, typing), proof-reading, spelling and the other skills associated with putting thoughts down on paper. We will be further challenged by the availability of affordable reliable optical readers, and by the advent of voice input for textual material.

3.2.2 Spreadsheets

Spreadsheet analysis of numerical data may be considered the original task of computers. Because these data are susceptible to compact representation and manipulation in digital computers, their management was both a strong motivator and important application of this technology. As computers have become smaller, more affordable, and friendlier, sophisticated and compact software known as 'spreadsheets' has become popular. Numerical data are contained in a matrix of cells arranged in columns and rows. Relationships among these data cells are readily defined, and as

new data are added or substituted, all interacting cells are recalculated. This has led to what is termed 'what if' analysis: what if I change this interest rate, this constant, or this equation? The redefined values are incorporated and the new results made available almost immediately.

3.2.3 Database Management

Database management, originally the province of mainframe computers, can now be carried out on the more powerful microcomputers. Database management refers to the creation and use of databases in which a variety of information is stored. Search strategies permit the sorting and retrieval of information by defining the relationship of various pieces of information to each other. For example, a database might be a student roster in which persons are grouped by name, initial, age, sex, address, phone number, courses taken, and so on. Large databases contain catalogues of professional information, such as articles, references, and categories of experimental data. For example, the Toronto Globe and Mail offers Infoglobe service, which provides on-line information on articles published in that newspaper since November of 1977.

3.2.4 Graphics

Graphic presentation of data showing proportions, trends, and relationships have long been used by scientists, industrialists, and market analysts. These graphs were largely prepared by hand. Today, the availability of inexpensive software and hardware which can readily accept data input from instruments, from the keyboard, and from spreadsheets and databases, has enabled use of graphical representations that previously would have required excessive effort for the benefit derived. As sections 5.3.2 and 5.4 indicate practitioners in arts design and broadcast industries also make extensive and innovative use of the graphics capabilities of computers.

3.2.5 Telecommunications

Today's communications technology permits the high-speed transmission of increasingly large amounts of data, which can be both sent and received by computers. A simple example of extending the power of computers through combining them with communications technology is the local area network, (LAN) used to connect computers within a room or building. These networks were pioneered in schools as a means of economizing on disk drives and printers. With the advent of hard disks with large data capacities on microcomputers, networks are being used, both in schools and business offices, to "cluster" microcomputers around a central data source. For distances extending beyond the building housing a computer, telecommunications (such as phone lines or satellites) can be used

for such services as bulletin board, computer conferencing, and on-line inquiry of large database utilities. Bulletin board services allow users to enter messages to be read by others but have limited capacity; usually, only one user may connect at a time. Computer conferencing services furnished by major data processing centres provide both an information exchange and social forum. Messages may be sent and received; programs may be placed in the "library" - a storage area - and recalled or "downloaded" by users; and "direct" conversations and conferencing may be organized among groups of users connected to the system at the same time.

3.2.6 Integrated Software

When several of these applications are combined in a single operating environment, the term "integrated software" is used. Most of it, e.g., combined spreadsheet, word processing, database and graphics, is notable for the easy sharing of data, graphics, and text which it permits. In terms of human productivity, the ability to move effortlessly within and among these applications is probably more important than simultaneous availability of all functions. Tight linkages among the various functions is another important attribute. Where such 'hard linkages' exist, for example, between a spreadsheet, a graphics program, and a database, the updating of information in database or spreadsheet will be reflected in other parts of the set -- graphs produced will be of the most recent data set, and calculations will reflect the most recent changes.

4.0 GENERAL IMPLICATIONS OF COMPUTER/COMMUNICATIONS TECHNOLOGIES FOR SOCIETY

4.1 Philosophical Issues

Current computer/communications technology may be seen as sophisticated tools to aid human learning and productivity and to broaden human experience. However, as advancing techniques in artificial intelligence, input/output interfaces, inexpensive mass storage, and portable yet powerful machines become increasingly part of our lives, the role these technologies should play in the education and socialization of present and future generations must be examined. Their widespread introduction into society raises significant philosophical issues with broad ethical implications.

Without clear principles governing the why, when, where, how, and what of computer technology, it silently but pervasively imposes its own biases. Computers are increasingly influencing social organization in offices and

factories, and may eventually do so in schools as well. They exert a marked effect on the economy, since their bias is toward knowledge - intensive industries staffed by specialists. Computer technology fosters certain values (the "technological imperative"), which tend to filter into society without critical examination, as well as an image of a desirable future (the information society). Finally, the technology carries implications for political organization and activity, since it lends itself to the centralization of control and the creation of elites.

For better or worse, computer technology has become part of our culture, in fact, is in the process of changing it. If the change is to be directed toward what we as a society want, then a philosophy -- a vision -- must be articulated that will permit us to think critically about both the positive and negative aspects of computer technology. This vision must provide us with standards of judgment and ideals of conduct relevant to the "society of the super-chip". There is no going back to a pre-computer technology culture; principles must be thought anew. The process of re-thinking and debate must include the people who govern the ideas, attitudes, and practices of the present era of technological transition, for it is they who will heavily influence the attitudes of future generations.

Although debate must go beyond simply categorizing effects as "good" or "bad", there are important ethical issues associated with every technology. These arise when we have to choose how technologies are to be used. Typically, the western industrialized societies have been enthralled by technological breakthroughs and preoccupied with applications, especially those with an economic pay-off -- tendencies reflected in low levels of concern for the safety of users. About a quarter-century passed, for example, between the time when automobile speeds of 100 k/hr became the norm and the introduction of safety features such as seatbelts. A similar lag in addressing ethical issues is evident in the case of many technologies; questions of environmental impact and appropriate use of resources, for example, remain unresolved.

4.2 Three Perspectives of Computer Technology

In general terms, Canadians exhibit three philosophical perspectives on computer technology and its impact on our culture. Each perspective offers different standards by which to measure the quality of the cultural impact and assess both its merits and drawbacks. These competing perspectives, which can be termed "computer humanism", "computer dread", and "computer realism", represent the main positions currently being taken.

4.2.1 Computer Humanism

Viewing computer technology as potential human freedom, humanists seek to draw out and enhance the

possibilities any technology holds for the development of a civilization founded on reason, community, and individualism. For computer humanists, the good society consists of free communication among a community of creative individuals. For example, the network "Swift Current", which provides a database of contemporary Canadian writing, is more than a project for poets and writers working collectively; from the perspective of computer humanism, it embodies the ideal of a creative educational experience and the good human society.

4.2.2 Computer Dread

The opposite of computer humanism is computer dread. Assuming that technology means dependency, computer dread explores the ways by which computer technology blocks human possibilities and indigenous cultural development. Emphasis on "high technology" is wrong, for instance, because it encourages a technology-intensive employment strategy that aggravates unemployment and further skews Canada's uneven economic development. Computer dread has its exponents among employees in office automation systems, who fear that the computer screen is the point where the machine begins surveillance of its human agents: the monitoring of keystrokes per hour among secretaries or the rate and timing of information/dialling responses by switchboard operators. The capacity of computers to store vast amounts of information, the ease of cross-referencing and retrieval, and the difficulty of controlling access to stored data raise concerns about the protection of individual privacy. Information collected for legitimate purposes could conceivably be employed for other ends.

4.2.3 Computer Realism

Computer realism, however, holds that by nature computer technology is neither emancipatory nor oppressive. It is embedded in economic and social contexts which determine its application. These must be carefully studied in order to ensure that computer applications preserve and enhance humane values rather than erode them. The direction of technological change is not inevitable, but depends on social choice. The fate of the information society depends on the creation of standards to measure the social and cultural impact of computer technology. These ethical standards include creative freedom, social solidarity, economic justice, and democratic self-management. An awareness of these standards and the ability to apply them should form the basis of computer literacy.

Computer realists seek to discover ways by which computer technology itself might become an ethical

process, a means of realizing the values inherent in these standards, as suggested below:

- creative freedom: computer technology as a means of realizing new human possibilities, whether by enhancing awareness or by expanding access to information;
- social solidarity: Does computer technology improve social relationships through networking, for example, or does it impoverish them by limiting access to information to a 'computer elite'?
- economic justice: Is computer technology limited by its subordination to the principle of private property? Could technology be a creative means for rethinking and rearranging our traditional approaches to education, work, and cultural life?
- democratic self-management: Is computer technology in the form, for example, of the "automated office system" an instrument of power in the workplace? Or could the use of computer technology be a creative process for the democratization of life, from workplace to government?

5.0 IMPLICATIONS OF COMPUTER/COMMUNICATIONS TECHNOLOGIES FOR SPECIFIC ASPECTS OF SOCIETY

This section looks at current and potential impacts of computer/communications technology on specific aspects of Canadian life and society. First, the implications for the economy as a whole are explored, along with the effects on the nature of jobs and their likely availability during the next decade. The section then describes the developments that computer technology is bringing to a variety of fields -- publishing, graphic arts, music, fashion and textile design, film, and video -- and briefly examines computer-aided design and manufacture of man-made objects. As an example of the impact of the technology in a particular sector of the economy, the application of computers to the broadcast industry is described in some detail. Finally, use of computer technology in the physical and life sciences, both pure and applied, is briefly reviewed.

5.1 The Canadian Economy

Science and technology have become the strongest and most profound influences of our age, making innovation in both product and process the norm in our economy. Systems thinking or systematic problem-solving is becoming all-pervasive, transforming the organization and even the culture of many areas of human activity. In combination with new tools and technologies such as robotics, computer graphics, artificial intelligence, biotechnology and telecommunications, it is shaping the economy of the post-industrial era.

Systematic thinking and scientific management are technologies in their own right; they make people think and act in certain ways -- more precisely, more systematically and more in terms of standardized procedures and formats. There is an important place for intuition, but when creative thinking is over, expediting decisions and getting things done increasingly takes the form of standardized actions, which can be delegated from professional onto semi-professional shoulders.

Much administrative and clerical work is becoming redundant, since the management information systems created through the integration of computers with communications offer a wide range of automated services. According to surveys done for the Ontario Task Force on Employment and New Technology (1985), Ontario-based companies involved in the service industries plan extensive investments in new technology between 1985 and 1990 -- particularly in office automation, customer-service delivery (automatic tellers and point-of-sale terminals in supermarkets and gas stations), and telecommunications.

In secondary manufacturing, the trends are similar. A handful of large companies, generally in the more modern business of electric and electronic manufacturing, have reached the stage of integration. Sophisticated information systems linking robots on the factory floor with the inventory-management system in the warehouse allow for a synchronized flow of parts onto the factory floor and of finished products into the warehouse, ready for shipment. Traditional delays are eliminated, along with some factory and warehouse workers. Research done for the Ontario Task Force suggests that technological upgrading will continue to be a priority among secondary manufacturers.

While Canadian robotics productivity is dwarfed by the achievements of Japan and the U.S., it compares favourably with countries closer to Canada in population and economic history. As well, the new generation of smaller robots is more attuned to Canadian industry, and represents an opening for Canadians within this field. There are already distinct specializations related to factory automation, robots for nuclear power plants and other hazardous environments and robots for riverbeds and ocean floors.

An increasing number of business corporations now trade, not in the traditional commodities, but rather in information. The concept of information as a commodity that enriches the economy, while not new, is difficult to picture and hence tends to be poorly understood. In the future, however, information is widely predicted to become the most important commodity in the economy.

5.2 Impact on the Workplace

5.2.1 Erosion and Deskilling of Jobs

Few if any occupations and places of work will remain unaffected by computer technologies. All work is becoming more technologically intensive. Technological change is resulting in an erosion and deskilling of work at lower and middle levels of administration and administrative support (clerical tasks); an upgrading of work at the professional and senior management levels; and the consequent development of a skills gap. These trends raise the possibility that ever-larger numbers of people will not be employed to the full extent of their talents, education and ambitions, but only to the tips of their fingers; such an outcome will have significant social and political as well as economic implications.

Erosion of work is already showing up in hours worked per week among different occupational groups. The only ones indicating an increase are in the highly skilled category of professional/management and in the service occupations -- fast-food restaurant workers and the like -- where most of the new jobs have been created since 1980. A growing proportion of the latter are in the 20-hour-a-week category.

5.2.2 Where the Jobs Will Be

Five major occupational groups have been identified by the Ontario Task Force on Employment and the New Technologies as likely to account for most (70%) of employment growth over the next decade. These are service work, natural sciences, engineering and mathematics, managerial, and administration. The only occupations expected to increase their share of employment over the next decade are the highly skilled professions associated with the natural sciences, engineering and mathematics, as well as unskilled occupations in the service industries. Specifically, jobs will be found in the fields of telecommunications, aerospace and application of new biotechnologies to farming, fishing and forestry.

Canada is already a world leader in satellite technology and telephone communication equipment. Telecommunications goods and services are likely to become further enhanced through incorporation of computers, in the form of micro-chips. For example, at least one Canadian telephone company is launching a meter-reading service, in which a micro-chip-powered device attached to a water or power meter will relay the readings over the telephone line when "polled" by the accounting office. Similarly, firms specializing in business services are likely to keep expanding their traditional bases of accounting and financial consulting

into more sophisticated computer-based information services and systems, such as electronic mail, payroll, and inventory management. Aerospace and related parts and instrumentation represents another area of strength in Canada.

5.2.3 Future Employment Trends

To sum up, there are three major employment trends to watch for over the next ten years:

- Jobless economic growth. Computerized information and manufacturing systems greatly increase productivity, thereby enabling the economy to grow without an increase in hirings.
- Polarization of the labour force. Statistical trends indicate that most new employment growth is in low-paying, low-skilled occupations, generally in the service industries, and in certain highly skilled professions. The resultant skills gap could polarize the labour force. This, and the meaningfulness of work, could become the major social issues of the 1990s.
- Escalating competition and requirements for jobs in the professional/managerial occupations. While the demand for engineers, mathematicians, computer scientists and the like will continue to grow, the numbers of professionals required in any one firm or industry will likely never reach the scale associated with the industrial age.

5.3 Publishing and the Arts

5.3.1 Publishing

In the next decade, computer/communications technology promises to reorganize North American publishing and transform our notions of libraries. Initially, major publishers are likely to collaborate in opening their own retail outlets in large cities; these will be electronic bookstores that in a small space offer the complete lists of the participating publishers. An early form of such publishing is now offered in Toronto by 'Swift Current On-Line Texts', which provides a database of contemporary Canadian writing. Users can select, download, and print materials for classroom use, creating their own anthologies.

Customers in electronic bookstores will view sample copies, or search the publishers' catalogues through colour monitors. Once selected, a book will be sent electronically from the publisher's national database, printed on a high-speed laser printer, and perfect bound -- within a ten-minute period. Users who prefer to purchase a book in electronic form will likely be able to subscribe to the publisher's database.

5.3.2 Arts and Design Fields

Writers, artists, musicians, and designers are incorporating computer technology into their work. Writers and editors use computers for word processing. Graphic artists, illustrators and television and film animators are increasingly using them as a creative tool. Fashion designers of the future will not only use computer-aided design, but also do computer simulations, comparing the unit price of a garment design in two colours versus three, or using cotton from Argentina versus silk from India. Architects are already using computers to draw blueprints as well as to calculate the most efficient locations and routes for electric and other utilities.

Musicians and students of music have available the Musical Instrument Digital Interface, (MIDI) which permits ease of interconnection between a computer and an electronic synthesizer, a keyboard instrument similar to an electronic organ. Music may be entered at the keyboard and transferred to the computer, where it can be stored, modified, transposed, or changed in speed. Subsequently, the music may be sent back to the synthesizer and played automatically. A system of this type can produce excellent music or perform simpler tasks, such as demonstrating musical theory or helping with ear training.

Graphic design is probably the most advanced area of computer use in the arts. Industry equipment and software range from inexpensive microcomputer applications packages to powerful graphics workstations that allow symbols and charts to be created, manipulated, combined with text, and presented in just about any combination of colours.

The use of computer graphics in textile design offer similar advantages. Computers readily lead themselves to creating individual design elements in any number of colours, and to combining and repeating them in two-dimensional patterns; even microcomputers can be programmed to translate textile designs into weaving patterns.

5.3.3 Film and Video

In film animation, large computers can generate increasingly realistic visual simulations of objects and landscapes, and allow their integration in complex gaming and environmental simulations. The ability to create simple two-dimensional animation sequences on desktop computers will create markets for low-cost productions, as computer animation becomes more broadly established.

Video has the potential of becoming a new art form through application of computer graphics techniques to the generating and enhancement of images, and their combination with rhythms and music created on digital synthesizers. Since their production is no longer expensive, videos may well become the dominant new art form of our time.

In future, artists in all fields will likely have to be more aware of the uses of computer technology, and, on their part, technologists will have to sharpen their artistic sensibilities. In this way, the skills and talents of both can be combined to produce works of art on a scale hitherto unprecedented.

5.3.4 Computer-Aided Design (CAD) /Computer-Aided Manufacturing (CAM)/Computer-Integrated Manufacturing (CIM)

The design and production of man-made objects are being increasingly influenced through the use of computers. The following information describes the processes involved -- computer-aided design, computer-aided manufacturing, computer-integrated manufacturing.

Computer-aided design (CAD) involves the use of computers, software, and a variety of hardware to produce many types of drawings. Common drawing applications of CAD include: mechanical, architectural, electrical, electronic, and civil. In addition to automated drafting, CAD permits the designer to use computer graphics technology in the design process. Working interactively with a graphics terminal the designer can create the visual geometry of the product being designed, then store data for instant recall. Some CAD systems can be used to create a three-dimensional model of the product in final form and conduct engineering tests prior to construction of a prototype or hard model.

Computer-aided manufacturing (CAM) automates manufacturing operations using computer-controlled machines and robots for material handling, and for fabricating, assembling, measuring and inspecting the product. In its basic form, CAM uses the data generated and stored by CAD to create manufacturing processes and instructions for numerically-controlled (NC) machines. It involves the use of a wide range of "intelligent" machine tools, sensors and other computer-based equipment to control the manufacturing process. Computer-integrated manufacturing (CIM) is the total automation and computerization of the manufacturing process from receipt of the order through design and manufacturing stages to shipment of completed order.

5.4 Broadcast Industry

Although many broadcasters were brought into the computer age reluctantly, the results have been impressive, particularly in view of the fact that the current level of computer use has been achieved with a minimum of 'on staff' computer expertise. With few exceptions, broadcasters utilize 'turnkey' software packages, basic software used across North America.

The gradual conversion to computer technology was stimulated by the increasing complexities of the broadcasting industry. The standard airtime unit changed from 60 seconds to 30, airtime costs grew significantly, and regulations on the content of commercials became more restrictive. The industry thus sought help in computers.

In general, the broadcast industry is proceeding toward computer automation on a pragmatic basis. Conversions have been made for some functions, such as marketing and accounting, while for others, such as programming and newsroom activities, production, and engineering, applications are just coming on the market. Some developments have been little short of spectacular; full-colour pictures on video recorders are now built right into cameras that weigh and cost a fraction of earlier models. News film has been replaced by 'electronic news gathering' near, and today's sophisticated editing capabilities provide a level of creativity and experimentation previously impossible. With new "digital special effects", pictures zoom, are squeezed, flip, rotate and explode. "Electronic graphics" are used to create high-quality titles, charts, and surprising animation. Linked to weather satellites, they allow us to view our world in ways we wouldn't have dreamed of a few short years ago.

How computerization spreads through station departments depends largely on the priorities and influence of specific departments. One station may have expanded the financial areas, another programming, control room automation, newsroom word processing, or demographic sales support. Increasingly, stand-alone or interfaced systems are being developed in-house by staff who know the station's requirements best. This trend has intensified in numbers and sophistication over the past few years, spurred by the availability of micro-systems and generic software tools (such as spreadsheet and database packages). Meanwhile, the major suppliers see new market potential developing, and are moving in.

Cable companies, for example, require systems to help administer fast-growing numbers of customer accounts and to track and respond to trouble calls. On the horizon are the installation of decoders permitting companies to bill subscribers per program viewed, the sale of advertising time on specialty channels, and the provision of home security systems offering fire and burglary alarms and medical alerts around the clock.

In future, we will see an ever-increasing interweaving of systems. Airtime will be sold and confirmed, changes notified and accepted, media time scheduled, and invoices released -- all electronically. This electronic interchange will also include the rating companies who monitor/assess the popularity of radio and TV stations on behalf of advertisers, agencies, stations and networks. Technically, the capability exists already, but many procedural questions still must be resolved.

Since security is a prime consideration, operating efficiencies will be higher if there is true compatibility between systems. Many station staff work in multiple databases in the course of a day and the terminal on the desk should be able to take them into each area. A producer might reference scheduling plans in the programming system, future 'logs/format detail' in the traffic system, crew/facilities availabilities in the operations system, and stock footage from the newsroom archives, and will certainly be checking his or her electronic mailbox for messages and correspondence.

5.5 Physical and Life Sciences

Basic physical sciences can mean mathematics, physics, chemistry; applied physical sciences can include engineering, astronomy, and geology. Basic life sciences can mean biochemistry, biology, physiology and pharmacology; applied life sciences can include agriculture, veterinary science, medicine, nursing, and pharmacy.

In addition, combinations of basic and applied sciences are resulting in the emergence of such new fields as biotechnology. This technology, which combines chemistry and biology with engineering and mathematics, is young but rapidly developing. A Science Council of Canada report, Seeds of Renewal (1985) predicted that "by 1995 biotechnology will supply the bulk of food additives; genetic stock enhancement through embryo transplants will affect 30 per cent of cattle; 20 per cent of all Canadian crops will have been developed through biotechnological processes; and 15 per cent of stock feed will be produced using biotechnology". Ontario has some 25 biotechnology firms, ranging in activity from mineral leaching (for mining) to ferments used in food processing.

Within these fields, computer technology is being employed in a wide variety of ways: education and training, research, professional activity such as treatment, and administrative or managerial functions. In varying degrees these involve forms of data acquisition and numerical computation; modelling, simulation, process control, and robotics; monitoring and various 'drudgery tasks'; diagnostic support, and image processing. Perhaps the most impressive application of computers in the physical and life sciences has been the multitude of tasks successfully taken over by microcomputers (of increasing power) and relatively small minicomputers. On the distant horizon are "expert systems" based on artificial

intelligence techniques. Although a few such systems have been designed, they are difficult to develop, and so their use to date has been very limited.

People who apply knowledge from these sciences, including doctors, dentists, nurses and dental hygienists, are becoming familiar with more and more computer-based equipment for diagnosis as well as treatment. They are reducing their operating costs and stress levels, as they learn how to put the computer to the most efficient use in managing the medical or dental clinic, maintaining patient files and managing inventories and payroll, timetables and the complexities of billing.

Future opportunities will be governed by technological developments in hardware and software techniques as well as by the attitudes of potential users. In the life and physical sciences, a large base of installed computers will be added to and modified by persons who see their usefulness in their working lives -- for ordering their databases, analyzing their experimental results, and modelling the processes that are the target of their investigations.

6.0 IMPLICATIONS OF COMPUTER/COMMUNICATIONS TECHNOLOGIES FOR THE INDIVIDUAL

Introduction of computer/communications technology will affect individuals in virtually every aspect of their daily lives -- in the business office, on the factory floor, in the art or music studio, and at home. Advances in communications technology, for example, have aroused much speculation about the possibilities of banking, shopping, and other activities being carried out from the home, and about the re-emergence of cottage industries -- the embodiment of the global village. Database management companies already provide electronic catalogue shopping and enable users to call up such information as stock quotations, airline schedules, and sports results.

Since most current discussion has tended to focus on the impact of technology on the individual as worker, this section deals principally with the skills and attitudes that workers, whatever their level, will require as the new technology plays an ever-larger role in their on-the-job functions.

6.1 New Skills in the Workplace

Most new employment is expected to be in traditional areas of work transformed to some extent by computer and other technologies. Increasingly, computers in particular will function as mediators between workers and the tasks to be performed.

6.1.1 Skills in Exploiting the Potential of Computers

Managers in all fields should be able to define their needs and problems clearly, and to identify the people with the technical expertise to help them solve the problems through the application of computer technology. Managers need not know how to write a computer program. However, they will need to know how to apply computer programs in their particular areas of work, so that tasks can be accomplished more quickly and effectively. Middle managers, for example, have found in computers a tool to extract accurate information; they can now focus more on exceptions before taking action, and waste less time dealing with discrepancies afterwards.

At the level of office manager, the generalist is giving way to the professional with computer skills to match particular ways of dealing with information: acquiring and organizing it versus selecting and using it. For example, a manager of finance will be familiar with standard spreadsheet software and be capable of sophisticated computer modelling for financial planning and organization. A manager specializing in industrial relations might wish to consult the computer-based reference services, for instance, of Quic Law, to discover the latest legal thinking on some matter coming up for negotiation in the next round of contract talks.

Social workers might find themselves using many computer-based information services, for instance, to put a handicapped client in touch with a company or non-profit organization which designs furniture and appliances for the physically handicapped; the Canadian Government is developing just such a database service. A chef might search a database for nutrition-related information, or use the computer to work out the most cost-effective combination of items for a hospital menu.

6.1.2 Importance of Broad Knowledge of Computer Applications

Perhaps the most important skill will be knowing how to employ the capabilities of the computer in a wide variety of tasks. The rising unemployment rate of computer programmers and systems analysts strongly suggests that people with a narrow specialization in computer science are not as employable as those who can apply relevant computer skills in a host of traditional occupations and, by working with computer-based information and manufacturing systems, help take the economy into new, more technologically intensive directions.

For instance, in the broadcast field, station managers recognize that in order to get maximum performance

from computerized systems within stations, a higher degree of local management of these systems is required. In order of importance, the attributes of the kind of employee who can best provide a higher level of utilization for existing systems are:

- knowledge of broadcasting
- awareness of station policies and procedures
- basic experience with the specific software in use: system conventions, features and limitations
- computer training beyond 'computer fundamentals' and basic hardware configuration training
- ability to use existing systems to greater advantage than intended by the original design

As the order of attributes reveals, station managers recognize that it is easier and more productive to train a broadcaster about specific areas of computers than to train a computer person about the complexities of broadcasting. Nonetheless, potential employees will be increasingly evaluated on their basic knowledge of computer technology. Employers in technical positions would, of course, be expected to have a solid grounding in their particular areas of technology.

6.1.3 Emergence of New Kinds of Professionals to Process Information

Use of computer technology may require new skills, and thus new types of "information professionals". These could include not only brokers who gather information using traditional librarian skills, but information "transformers" who interpret information within the context of those who need to use it. One example might be interpreting the realities of the engineering-design team to the marketing personnel who must sell the products developed by the engineers, and interpreting the realities of market opportunities and consumer taste to the professionals in product development.

The sheer volume of information now readily accessible presents new problems. Since obviously not all the information is relevant to a particular task or all of it equally reliable, we need ways to assess the quality of the information. The nurture, assessment, and preservation of information are crucial to any successful society; of these three, assessment is both the most vital and least understood. If individuals and society are to profit from the current abundance of information, both systems and skilled professionals are needed to carry out this assessment function.

6.1.4 New Directions for Artists and Designers

Computer technology is expected to have a powerful impact on the way art is produced, and to foster higher productivity in the applied arts. To make the most of the emerging possibilities for creating and using computer-generated images and sound, artists must be willing to experiment and to work with a wide variety of people with technical expertise. Architecture, environmental and product design, graphic art and music will all involve the use of computers in the future. Trends in film and video production, band concerts and recording suggest the need for a level of integration of artistic and technical skills unprecedented in the West since the peak of the cathedral building boom of the Middle Ages.

6.1.5 Increased Delegation of Routine Tasks

Skill in delegating responsibility for certain routine tasks may assume greater importance as a result of increased reliance on the technology of systems management. It enables decisions reached by professionals to be implemented through standardized actions carried out by workers in semi-professional categories. In the field of social work, for example, the community-college trained community worker is expected to handle the technical work of expediting the flow of welfare, UIC and other payments, freeing the social worker for counselling and other professional tasks.

6.1.6 Opportunities for Synergy

Computers offer high potential for synergy, since they serve as unifying devices which enable one to make effective use of a wide range of machines -- some familiar and friendly, like the telephone, and others still possibly foreign and a little fearsome. So far, we have little experience of the synergy that could be available, nor have the social sciences provided us with the knowledge we require to generate a significant amount of social synergy.

One promising but little explored technique for achieving synergy is shared information space. Shared space linkage of computers is intended to create a graphic or textual shared information space analogous to the acoustic shared space of the telephone. It can be achieved by making all participants' screens and keyboards behave identically, so that every individual keyboard entry, from any of the linked machines, appears as if it had originated on all of them simultaneously. When two or more people use machines linked in this fashion, and are also connected by telephone, they are sharing a common information space for voice and data. Early work at

Bell-Northern Research indicated that people working this way frequently experienced a kind of intellectual synergy that could be an asset in dealing with a world of ever-increasing complexity.

This application of computer technology could be a significant tool in the workplace. However, new levels of co-worker trust and cooperation would be necessary. Where people are working toward a common goal, shared communication becomes a useful part of the growth process.

6.2 Attitudes Toward the Use of Computer Technology

The smooth integration of computer technologies with day-to-day work depends more on the attitudes, skills, and knowledge of both supervisors and staff than on the capabilities of the technology itself. The role of the executive is crucial, demanding a genuine interest in using this technology, knowledge of its limitations, a sensitivity to what is and is not possible, and what outcomes may reasonably be expected. Even if employees are eager to use computer technology in their problem-solving, a negative attitude on the part of an immediate supervisor or executive officer can frustrate the integration of computer solutions into work activities.

Since most skills in using computer technologies can be learned with relative ease, attitudinal problems are frequently the more difficult obstacle to overcome. Negative attitudes may arise from philosophical reservation, previous experience, fear of the unknown, or fear that job function or security will be adversely affected. Most of these problems can be resolved through discussion in a supportive atmosphere.

Future opportunities will be governed by developments in hardware and software techniques, but more importantly, by the imagination, attitude and creativity of those generating applications software, and by the sensitivity and wisdom of those guiding the deployment of this technology in our society.

One manifestation of wisdom will be the ability to recognize and admit when use of technology may not be filling a real need -- may not, in cost-benefit terms, improve quality or quantity. There will be occasions when it may actually worsen the working environment by diminishing the need for professional or craft skills on which quality of product and satisfaction of the producer depend.

7.0 IMPLICATIONS OF COMPUTER/COMMUNICATIONS TECHNOLOGIES FOR EDUCATION, THE SCHOOL, AND THE LEARNER

7.1 Implications for Education

7.1.1 Factors Governing the Introduction of Computers Into Education

In the early 1980s, educational institutions found themselves in the vanguard of social change. Many educators were surprised to be thrown into wide-ranging discussion about the applications of computer technology to their field. Enough dust has now settled to permit a fairly clear view of the significant issues.

In retrospect, many of the expectations held by some teachers and many members of the public were unrealistic. Even though the rate of technological and social change is much faster than in previous times, for the majority of people and institutions the sorts of changes predicted by Alvin Toffler in The Third Wave (1980) will take place over decades rather than years. Unfortunately, the media have created a set of expectations around the idea of 'instantaneous transformation', and have thus made the long-term realization of a positive transformation much more difficult.

Among the groups challenged by the 'third wave' were manufacturers and educators. Coming at a time when industry in North America and Western Europe was feeling the effects of competition from Japan, the prospect of legions of assembly-line robots sent shivers of fear through boardroom and union hall alike. Just as the machines of the second wave replaced human muscle, the devices of the computer technology wave could be seen as amplifiers of the human brain. Education seemed to many observers the most natural place to "apply" these machines.

During this period two independent but parallel forces sustained the image of an education system in need, and on the verge of, radical change based on the introduction of computer-based materials. The first of these was a small group of educators who were intrigued by the potential of the technology and adventurous enough to experiment. The second was the section of the microcomputer industry which believed it could profit from a concerted advertising campaign aimed first at parents, then at teachers and other educational decision-makers. It implied that parents and educators were failing in their duties if they did not invest heavily in microcomputer hardware and software.

As a result, the period from 1980 to 1985 has been one of experimentation with computers in school. These experiments frequently had limited hardware running mediocre, inadequately documented software under the guidance of a teacher with minimal training. It is difficult to argue that the experience of the average learner in his or her encounters with the classroom computer has been intellectually or socially significant. Yet it is on the basis of these initial experiences that many educators will form their views about the role of computer technology in education.

For much of this time, proponents of an increased role for computer technology in education met little public opposition. Many teachers had apprehensions, most frequently based on fear of the unknown, and resistance took the form of non-involvement. Many others took a wait-and-see attitude. The fervour of the anti-technology wing of the environmental movement seemed to have waned, but eventually a body of criticism developed. Joseph Weizenbaum, self-designated leader of the opposition at MIT, acquired an increasingly high profile, as the "techno-fix" dream began to fade. In late 1984 a watermark of sorts was passed when two journals dedicated theme issues to criticism of computer technology.

7.1.2 Key Questions About Computer Technology in Education

The appearance of progressively smaller, cheaper and more powerful computers raises the questions both of opportunity and of risk. Current technology is sufficiently powerful to give cause for serious reflection not so much on questions like "What will technology make possible in the future?" but more on "What are we going to do with what we have now?" There is scant evidence that we are adequately prepared for the richness of our present endowment. What then of opportunity present and future? In considering this question, educators need, above all, to understand clearly the principles underlying technological innovation rather than focus only on specific devices or systems. What is it, if anything, which makes the potential impact of computer/communications technology of sufficient magnitude and duration to cause us to re-evaluate our instructional methods, and to rethink the attitudes, knowledge, and skills which we wish to impart to our children?

7.2 Implications for The School

7.2.1 Expanding the School's Limits

Despite unrealistic expectations and unrealized hopes, there are a number of technological developments that can lead to beneficial change at the school level.

These include access to an increasingly wide range of databases, the development of specialized databases for local use, microcomputer networks, and computer software for conferencing purposes.

The use of computer/communications technology frees many areas of education from their traditional 'space-bound' reliance on physical facilities and the resources at hand. Although these will continue to be required for such pursuits as physical education, technical/vocational programs, theatre, and the arts, in academic areas where the chief resources are book and teacher, this reliance will no longer be inevitable.

7.2.2 The "Soft Library"

Over the next decade, for example, the book will decline in importance for certain purposes. It will become less important as a storage device, owing to the emergence of the 'soft library', a collection of on-line resources including works of literature, electronic periodicals, works in the pure, applied and social sciences, encyclopaedias, indexes and bibliographies. These will be available equally to urban and rural students and to small or large facilities. Many libraries already use microfiche and microfilm to store back issues of newspapers and magazines, and the Encyclopaedia Britannica is now available in an on-line edition. The 'soft library' can provide resources that teachers now obtain from a learning resource centre.

7.2.3 The "Soft Classroom"

The "soft classroom" will also come into existence, likely using the same computer technology as the soft library, requiring few physical facilities and allowing students to 'meet' on-line with an instructor and each other. The soft classroom has no physical location; students and teachers meet by sharing a small database structured specifically for their use. Students enter this classroom by dialling in to the database through a microcomputer and modem, from home, school, or other location. Once connected, a student can send electronic mail to the instructor or other students, post work for all to see, or send work to the teacher only.

This kind of classroom is ideally suited to courses for which there is insufficient demand within one school. It is also suitable for extra-curricular academic instruction, such as frequently is given to high school creative writing students, to a select group of talented students from a variety of schools, or to students confined at home because of illness or disability.

Students should be encouraged to view the soft classroom as a flexible one in which the "walls" and "furniture" can be moved whenever necessary. Participation in this "classroom without walls" is especially relevant in a culture such as ours, where a great deal of learning takes place outside formal institutions. For example, computer/communications technology wil enable students to extend the classroom, gaining access to a wide range of information stored in database and disseminating information to others with common interests.

Clearly, there will always be certain subjects or classroom activities in which the traditional face-to-face social interaction is desirable. Discussions of literature, history, current events, and values, for example, are likely to prove more spontaneous and vigorous when the students participating in them are in the same physical location.

7.2.4 Computer Conferencing

A network would provide teachers, administrators and ministry personnel with computer conferencing software that would allow consultation and debate on a continuing basis. In effect, such a facility would enable the creation of topic-oriented 'teacher centres', on-line discussion groups created by the participants to address issues of concern. Teachers from different parts of the province could collaborate in producing instructional materials, and take part in conferences that incurred no travel expenses or travel time.

7.3 The Learner and Learning

Although the feasibility of applying computer technology to educational uses is not in doubt, numerous theoretical and practical questions remain to be answered. Some of these relate to specific uses of this technology, while others challenge us to rethink traditional instructional practices and basic notions about the learning process. A fundamental question concerns the particular skills or knowledge acquired within the context of using computer technology. Research must then investigate the transferability of the skills or knowledge from using the technology to the broader classroom context and beyond the school.

7.3.1 Word Processing and Language Development

"Whole language" experts, for example, claim that since children learn language usage by using language, introducing a text-handling computer program will facilitate the child's language production. However, we need to know the learning processes that are enhanced if children are to take advantage of such a tool. Will computer use improve reading and writing